cause of injury. In the San Joaquin Valley the usual tule fog, which is a great protector against frost, was lacking. Most of the injury was done by the drop in December to 17° at Yuma, Mecca, Indio, Riverside, San Bernardino, Fresno, and so on north to Yuba City and Chico. In normal seasons young fig trees and the mamme crop will endure a temperature of 17°, and probably lower, without injury. These conditions may not happen again in a generation, and yet bearing trees of 6 and 7 years of age suffered no loss of wood, the damage being confined to the winter crop of caprifigs.

The best Capri trees.—There are now established in California, thanks chiefly to the United States Department of Agriculture, probably more capri varieties than are to be found in any other country in the world. We have most of the best from the Smyrna district of Asia Minor, many from Italy, Greece, the islands of the Mediterranean, and especially from the States of northern Africa, besides a host of seedlings of local origin.

Probably every Smyrna fig grower has observed the difference that exists in the ability of different varieties to carry through the winter crop. Many kinds never produce a mamme crop, though they generally yield the profichi in great abundance. Still others produce so few that they are of little use in perpetuating the blastophaga. Quite a number fail to bear a mammoni or late summer crop, or the figs come at a time that leaves a hiatus in the successive generations. Such trees can not produce a mamme crop unless they have the assistance of better trees, for it is well known that the mamme figs dry up and fall unless oviposited in by wasps of the mammoni generation. It is a curious fact that the egg of the blastophaga is just as essential to the caprifig as is the pollen grain to the Smyrna fig.

Careful investigations extending over a period of several years seem to indicate that the ability of a tree to successfully support the mamme crop through the winter is more a question of variety than of climate. Several instances are known where, in frosty portions of the San Joaquin Valley, single trees, unassisted by others in the neighborhood, have carried the different crops uninterruptedly for more than 40 years. The possession of such trees by the grower is of supreme importance.

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Preserving Mamme caprifigs.—After recommending a list of capri trees that when well established can be depended upon to carry the mamme figs through the severest winters yet experienced in California, it may seem superflous to describe a process by which these winter figs can be stored, safe from not only California frosts, but from those of regions where the temperature goes so low as to render it impossible to carry the insect from year to year and consequently to grow Smyrna figs.

Of the three crops of the capri tree, the mamme is vastly the most important, as both the others depend for existence on the insects which live through the winter in this crop. We may, therefore, truthfully say that the whole Smyrna fig industry is actually dependent on the mamme, for failure of this crop means ruin to the others.

The severe frosts of the past winter emphasized the fact that every precaution must be taken to save the mamme crop. A good deal of experimenting has been done with this end in view. George C. Roeding has diminished the loss somewhat by building light shelters of palm leaves or other light material over the trees, mounted on a framework supported on four posts. Experience has shown that it is not best to rely on the roof alone, for much better results are had when the sheltering cover extends down to within three or four feet of the ground on the sides exposed to the morning sun, so as to protect the figs, in case of frost, from too sudden thawing. This method, however, has been only partly effective. Another plan, tried by the writer, which has been fairly successful, is to cut from the tree in December, before the severe frosts, twigs bearing well-developed mamme and plant them in moist soil in the open air, leaving the figs above the surface. The branches should be planted where they would have some protection by trees or buildings from the severest frosts. In this way the caprifigs have been carried through the cool weather, and the insects issued in large numbers at the usual time in spring.

But another step has been taken in this direction by Henry Markarian, of Fresno, that deserves to rank as an important discovery. On the 5th of April last, at his place near Fresno, he handed the writer a dozen mamme figs which had been taken from the tree about the middle of December. These figs were carried to San Francisco in a paper bag and, on the 8th of April, were put into a fruit jar in order to prevent drying out. On the 13th, female blastophaga commenced to issue, and continued to do so every morning, in a sunny window, for more than two weeks. On the 20th they came out in a great rush from 9 a. m. until 10.30. The issue gradually decreased until the 29th, when the largest of the figs was cut open and was found to still contain some females that would have come out later. This fig, the best developed one of the lot, yielded by actual count over 600 females and about 150 males. This certainly is a remarkable demonstration of the efficacy of the plan.

Mr. Markarian's method is simplicity itself. The best developed and most perfect figs are taken from the tree in December before the advent of heavy frosts. They are then packed in a box of clean damp sand. First an inch of sand then a layer of figs, being particular not to let them touch each other or the side of the box, then another inch of sand, pressed down so as to completely envelop the figs, and so in alternate layers of sand and figs until the box is full. Top off with a final layer of sand and cover to prevent evaporation. The box, containing a thousand figs, was kept in a cellar where the temperature was about 55° to 60°. A few which had been frosted during the November freeze had molded, but all sound ones kept perfectly. In due season the figs were hung in his capri trees, and mature blastophaga came out as usual and entered the profichi crop. A surplus of figs was disposed of to neighbors and gave satisfaction.

By this plan the Smyrna fig growers can bid defiance to frost, and the mamme crop can be carried through winters in regions where the cold is too severe to render the growing of Smyrna figs otherwise practicable. In this way all trouble from loss of the winter crop in California and Arizona is obviated and may be the means of making it possible to grow the Smyrna fig all along the Gulf region of the Southern States from Florida to Texas. Another advantage of this plan is that the time of issue of the blastophaga can be regulated by changing the temperature of the storage room. If early insects are wanted, raise the temperature; if a later issue is desired, put the box in a little cooler place.

HEATING THE ATMOSPHERE.

By ALEXANDER G. MCADIE.

Sitting by an open fire, watching the coals burn, the thought may come that we are, indeed, burning ancient starshine. For the sun is of course a star, and, fortunately for our personal comfort, the only one near enough to present a face for study. The next nearest sun is 300,000 times as far away, or, in astronomical units, four light years distant. Therefore, we need not concern ourselves much about the amount of stellar energy other than solar intercepted by the earth and stored as fuel.

Now, the solar radiation does not fall directly upon the earth's surface, which, as will appear later, is also most fortunate for us; but falls upon a thin gaseous envelope and passes through this to the earth. Some of the solar energy is absorbed by the atmosphere, and for different rays the atmosphere has different coefficients of absorption. Some of the energy is reflected back into space. In fact, the albedo or proportion of reflection may be as much as 33 per cent. And, finally, some of the energy, especially some of the short waves, may undergo transformation in the higher levels, possibly through ionization. The chief absorbing medium in the lower air is water vapor, particularly effective with the long waves.

Abbot, Fowle, and Aldrich, in various reports of the work carried on at the astrophysical observatory, have fixed the average value of the solar constant of radiation at 1.925 calories per square centimeter per minute for the epoch 1905–1909. Higher values are to be expected during the sun spot minimum. For a sun spot cycle, 11.1 years, the average value may be taken as 1.95 calories.

In 1909 Abbot, using a spectrobolometer on the summit of Mount Whitney (14,502 feet), determined the energy distribution in the solar spectrum outside the atmosphere lying between wave lengths 0.29μ in the ultra-violet and 3.0μ in the infra-red.

The average temperature of the earth is 287° A. (absolute) and that of the upper atmosphere approximately 220° A. The apparent temperature of the sun, computed by various methods, ranges from 5,840° A. to 6,430° A.

If there were no atmosphere, the earth would receive heat during the day at a rapid rate and lose it rapidly during the night. Life in its present form would not be possible. But the atmosphere, and, as we shall see further on, the water vapor in particular, maintain conditions as we now know them.

In discussing the effect of the isothermal layer upon the temperature of the earth and lower atmosphere, Humphreys [1] shows that if this outer atmospheric shell lets in

[1] Bulletin Mount Weather Observatory, vol. 2, pt. 5, p. 288.

heat more rapidly than it lets it out, the inclosed object—the earth—will become warmer. Assuming that the earth radiates as a black body, the sum of the incident and reflected energy passing through the outer layer is approximately 4/3 of that originally incident, and the radiant energy received by the earth will be about 11 per cent greater than if there were no absorptive layer. The surface of the earth is therefore some 7° C. warmer than it would be without this absorbing layer. But this is a general statement, limited to the action of the isothermal layer alone. In fact, owing to the alternation of day and night, and changes due to the earth's motion in its orbit, the changing angle of incidence of the solar rays, and, above all, the varying distribution of water vapor over the earth, it is a difficult matter to estimate accurately the incoming and outgoing energy.

In the atmosphere itself the heat is not uniformly distributed for, as clouds form, the latent heat of condensation may cause peculiar temperature inversions; and, conversely, as the clouds become invisible, the latent heat of vaporization may also cause an inversion of temperature. Furthermore, there are various convectional gains and losses. The diurnal vertical convection is confined chiefly to the layers below 5,000 meters; but there are certain cyclonic circulations in which the convection extends to higher levels.

If the so-called solar constant were constant, the earth would receive in a year something over one million million million million calories of heat. In popular terms, this is sufficient heat to melt a layer of ice 33 meters (100 feet) thick over the entire earth's surface annually, or to evaporate 1.66 x 10^{13} kilograms of water. This, then, is what the surface of the earth would receive if there were no atmosphere, and absorbs if there were no reflection.

On the other hand, the surface receives heat from the interior, and a rough estimate of the amount may be obtained by multiplying the temperature gradient in the soil—1° C. for 35 meters—by the average thermal conductivity, which is .006 gram calories per square centimeter per second. According to Abbe and von Herrmann, the amount in a year is 54 calories per square centimeter, or sufficient to melt a layer of ice 7 millimeters thick (0.28 inch). From above and below, then, the atmosphere receives heat.

But the so-called solar constant is not constant, and solar physicists have of late noted changes. Abbot,[1] speaking of variations in his computed values of the solar constant of about 10 per cent states that a change of the intensity of solar radiation of 3½ per cent, due to the decrease in solar distance, occurs from August to October, and this is readily discernible in the work done on Mount Wilson; so that there can be little question that the changes noted there are really solar changes and not of atmospheric or accidental origin.

Kimball states:[2] "There is evidence that the so-called solar constant is a variable quantity. There is stronger evidence that the atmospheric transmissibility undergoes marked changes that are nearly synchronous over considerable portions of at least a hemisphere, and that diminished transmissibility is accompanied by a diminution in temperatures and in temperature amplitudes. Marked diminutions in atmospheric transmissibility occurred in 1884–1886 and 1903–4 that were undoubtedly connected with violent volcanic eruptions. Less marked diminutions occurred in 1891 and 1907 that have not yet been connected with phenomena of this nature."

[1] Annals of the Astrophysical Observatory, p. 235.
[2] Bulletin of Mount Weather Observatory, vol. 3, pt. 2, p. 117, Oct. 19, 1910.

The question then arises: If on the one hand the solar output varies and on the other the transmissibility of the atmosphere also varies according to its dust and vapor content, how are we to differentiate the effects if we make use only of surface temperatures? Accurate measurements of both should be made at widely separated stations. Abbott, from a comparison of temperatures at many points, concludes that certain abnormal temperature departures at continental stations are recognizable as due to change of solar radiation. At insular stations, however, the temperature departures are less marked.

Temperature abnormalities as shown in annual departures may throw some light upon variations in solar output. For this purpose long series of standardized observations are of unusual value, but one must be on guard for variations caused instrumentally.

Meteorologists are now paying special attention to the so-called permanent pressure areas or centers of action. Possibly future study of variations in location and intensity of these centers may lead to the detection of a relation with solar conditions. But at the present time the outlook is not promising. It may be said that there are at least five well-marked ocean highs in the belts of high pressure and two great lows. The intensities, durations, and surface temperatures of the great ocean currents are bound up with the position and strength of these centers.

We return, then, to our open fire and as we watch the coals burn, we realize that the processes through which the solar energy became converted into fuel and all the intermediate steps connected with the heating of the atmosphere are yet largely unknown and imperfectly understood. Assuming that a pound of the imprisoned starshine, or lump of fuel, has approximately 14,500 British thermal units, then the equivalent energy would be about eleven million foot-pounds or a million and more calories. But, as we saw at the beginning, this is practically the amount of solar energy which each square centimeter of the earth would intercept each year, provided the receiving surface were perpendicular to the sunbeam and that there were no atmosphere.

CONVENIENT CONVERSION TABLE FOR FROST WORK.

By A. G. McAdie.

Orchard heaters, evaporators, and frost protectors of various forms have come into such widespread use that a convenient table for the quick conversion of heat units into power units, and vice versa, seems to be much needed.

It may be pointed out that the British thermal unit is the quantity of heat required to raise the temperature of 1 pound of pure water at maximum density, 39.1° F., 1° F. This is the unit most frequently used by engineers in this country and Great Britain, although it is desirable that the old English units and the Fahrenheit scale be used as little as possible. A British thermal unit is equal to 0.252 calorie and also equal to 777.5 foot-pounds. One therm will raise the temperature of 1 gram of water 1° C.; 1,000 therms equal 1 calorie, equal to 3.968 British thermal units.

In problems connected with the heat of water, it should be remembered that the total heat is the latent heat plus the sensible heat. The total heat required to evaporate water at a given temperature is 1,059.7 +0.428 T, where T is given temperature. This holds for temperatures between 32° F. and 212° F.

In changing to steam at 212° F. a pound of water at 212° F. absorbs 970.4 British thermal units and the total heat is therefore 1,150.4 British thermal units. This is